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MINERALOGRAPHY AS AN AID TO MILLING[1]

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The accurate determination of the opaque minerals present in an ore is very often of prime importance to the mill-man if he would work out the problem of separation intelligently. It is sufficiently obvious that a chemical analysis or an assay will only give him data as to the elements present and will leave him more or less in the dark as to the minerals represented in the ore. Since it has been found that certain sulfides are more amenable to flotation methods than others, the value of accurate mineralogical determination of the ores would appear to be particularly necessary in this form of milling. However, it should also be quite evident that any milling problem would be benefited at its inception by a careful study of the mineral content of the ore, the approximate quantitative proportions of the minerals present, and their mutual inter-relationships.

As far as the writer is aware the only satisfactory method for examining these ores microscopically is by means of polished sections in reflected light. This branch of Mineralogy, known variously as Mineralography or Mineragraphy, may also be applied to the microscopic study of mill-products in the different stages of separation. Where the fragmental material is fairly coarse a thin layer of it may be set in melted sealing-wax and polished in the ordinary way. If the material is fine enough to pass through a 48-mesh screen, before polishing, it must be mixed with a combination of melted sealing-wax and balsam. This may conveniently be accomplished in a small porcelain dish in which the wax and balsam are melted, the powder being poured in and stirred all through the mixture. The grinding operations which are so useful with the coarser powders and with the solid sections, must be eliminated for these finer powders and a good part of the polishing must be done by hand on a rouge-block.

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[1] Presented at the annual meeting of the Mineralogical Society of America, Ann Arbor, Michigan, Dec. 29, 1922.

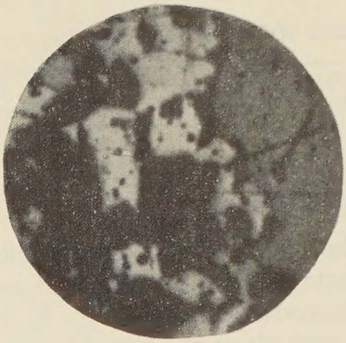

FIG. 1. Solid Section—White, pentlandite; gray, pyrrhotite; black, gangue. Magnification 150 ×.

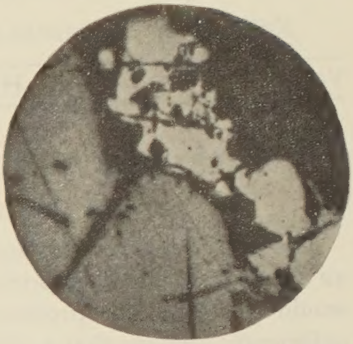

FIG. 2. Passed thru 20-mesh screen. White, pentlandite; gray, pyrrhotite; black, gangue and wax. Magnification 150 ×.

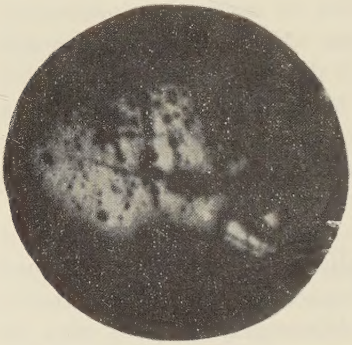

FIG. 3. Passed thru 48-mesh screen. White, pentlandite; light gray, pyrrhotite; black, gangue and wax. Magnification 150 ×.

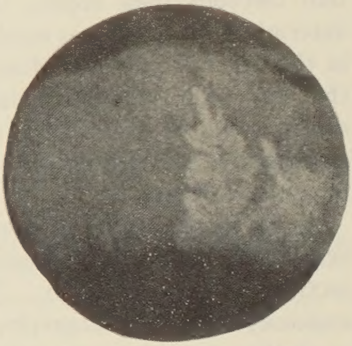

FIG. 4. Passed thru 100-mesh screen. White, pentlandite; gray, pyrrhotite; black, wax. Magnification 580 ×.

Recent investigations carried out by W. J. E. Wyllie, M. A. Sc.,[2] in the Mineralogical laboratories of the University of Toronto, demonstrated very effectively the value of this form of microscopic study, when applied to the examination of mill-products. In the experiments carried out by Mr. Wyllie, the nickeliferous pyrrhotite from the Creighton Mine, in the Sudbury District, was selected as providing suitable material to illustrate the value of this method. It was found from examination of polished sections

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[2] Wyllie, W. J. E.—"The Use of the Microscope in the Treatment of Ores." (Thesis for M. A. Sc. Degree.)

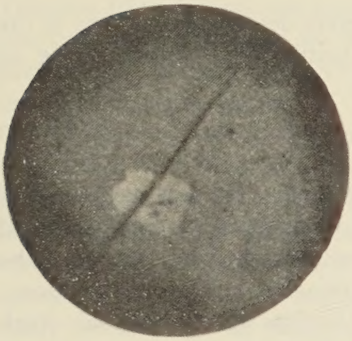

FIG. 5. Passed thru 200-mesh screen. White, pentlandite; gray, pyrrhotite; black, wax. Magnification 580 ×.

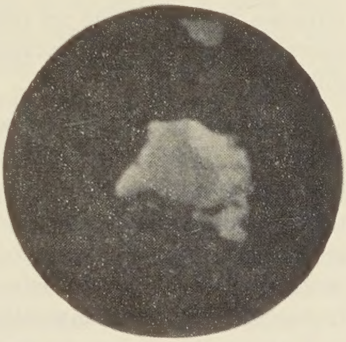

FIG. 6. Passed thru 300-mesh screen. White, pentlandite; gray, pyrrhotite; black, wax. Magnification 580 ×.

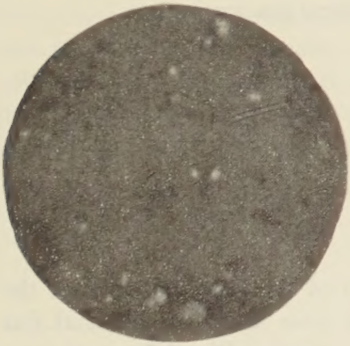

FIG. 7. Fine grained portion. White, galena; gray, sphalerite; black, gangue. Magnification 150 ×.

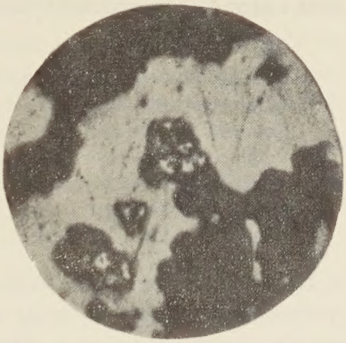

FIG. 8. Coarse grained portion. White, low relief, galena; white, high relief, pyrite; gray, sphalerite; black, gangue. Magnification 150 ×.

of the uncrushed ore that the nickel was present in the form of pentlandite and subsequent experiments with the mill-products demonstrated very clearly that it was present only in this form. A separation by magnetic means was attempted and the magnetic particles were examined in the successive stages of crushing, down to material that would pass through a 300-mesh screen, to determine the amount of pentlandite still adhering to the fragments of pyrrhotite. It was observed that even in the very fine material passing through the 300-mesh screen, some few particles of pentlandite remained. The quantitative proportions of the two minerals present in the ore powder were determined for two of the coarser sizes, the percentages of pentlandite present being as follows:

Material retained on 48-mesh screen	3.97%
Material retained on 100-mesh screen	3.33%

These results were obtained by careful counting and measuring of the individual mineral grains. This was done on a cross-sectioned ground-glass plate fitted to the mineralographic camera, the measurements of the two minerals giving the relative proportions. It was unfortunately impossible in the time allotted for this work to do more than a few sections of each of these two sizes. Much more accurate work would be possible, given more sections. Nevertheless from the following table of analyses, carried out on the different sizes, it will be seen that these quantitative determinations agree fairly well with the chemical proportions:

Size	% Ni
Retained on 48-mesh screen	1.70
Retained on 100-mesh screen	1.17
Retained on 150-mesh screen	1.06
Retained on 200-mesh screen	1.05
Retained on 260-mesh screen	0.94
Retained on 300-mesh screen	0.82
Passed 300-mesh screen	0.52

In figs. 1-6 the intimate association of the pentlandite with the pyrrhotite is shown in most of the sizes down to material fine enough to pass through a 300-mesh screen. Fig. 4 in particular, which shows material passed through a 100-mesh screen, exhibits an almost dendritic intergrowth between the two minerals. Both from the analyses and the microphotographs it would appear that separation of this ore by magnetic methods would require crushing to too fine a size to make it commercially feasible. The analyses alone would have told half the story and microscopic investigation completed the tale with striking illustrations.

Examples might be multiplied showing the value of the microscope to the mill-man, but it is not the writer's intention to introduce too many illustrations. One or two more cases might, however, be cited as furnishing striking examples of the value of the microscopic method of attack.

In the month of March, 1922, the writer was asked by Prof. L. J. Rogers of the Department of Chemistry, University of

Toronto, to undertake the microscopic investigation of some lead-zinc ores from Burmah. He wished to determine, if possible, approximately the proportions of galena and sphalerite present in the ore, the average size of the individual mineral grains, and their interrelationships. The ore as submitted was of two different types, one part being fine-grained (Fig. 7), and the other fairly coarse in texture (Fig. 8). The minerals present in the ore were chiefly galena and sphalerite, with minor amounts of pyrite, chalcopyrite, and tetrahedrite. By means of a cross-sectioned eye-piece set in the microscope, it was possible to determine fairly accurately the relative proportions of the two principal minerals, the average size of the individual mineral fragments, and the intimacy of their mutual crystallization. The fine-grained mixture was found to occupy 70% of the section, the coarse-grained mixture 30% of it. It was further determined that of the fine-grained portion, representing 70% of the whole, only 16% was occupied by fine specks of galena, the remainder largely by sphalerite; furthermore that of the galena in the fine-grained portion the following sizes occupied the relative areas indicated in the subjoined table:

DIAMETER	RELATIVE AREAS
.0004 in.	26%
.00075 in.	31%
.001 in.	27%
.0015 in.	12%
.002 in.	3%

The data thus collected proved of considerable value in determining the degree of crushing and the methods of separation to be employed generally. Much more complete information could have been collected for this material if the ore had been crushed to various sizes and the fragments examined for the two minerals. Unfortunately time was a prime factor in this case and further investigation of the sort was found impossible.

The ore from the Stemwinder Mine, near Kimberley, B. C., might serve as one more illustration. Costly laboratory investigations were carried out on this ore by numerous experimenters in the hope of arriving at some solution of this particular problem of separation by flotation methods. A very brief preliminary microscopic examination of the ore would have resulted in the elimination of some part at least of this experimenting and the expense incident thereto. Through the kindness of E. W. Todd of the Department of Mineralogy, University of Toronto, the writer was able to obtain for examination some of the ore from this mine. It is very fine-grained, with the three main constituents, sphalerite, pyrrhotite, and galena so intimately mixed as to require too fine crushing to accomplish a clean-cut separation.

A similar mixture of minerals obtains at the Sullivan Mine in the same district, but the individual mineral grains are larger in this ore making it more amenable to treatment.

From these few examples it would appear that a preliminary microscopic examination of any ore would be extremely useful in determining the kind of milling to be undertaken, that it is possible to examine all classes of fragmental material, down to that passing through a 300-mesh screen, and finally that without such microscopic investigation the mill-man is handicapped in the majority of cases.

AUGITE OF THE ALBAN HILLS, ITALY

H. S. Washington and H. E. Merwin, *Geophysical Laboratory, Carnegie Institution of Washington*

In a continuation of our study of volcanic augites, we have recently examined an augite from the Alban Hills, using material sent to us by Professor F. Millosevich, of the University of Rome, to whom we would express our sincere thanks. The material studied by us was used also by Drs. L. H. Adams and E. D. Williamson, of the Geophysical Laboratory, in their investigation of the compressibility of minerals and rocks.[1]

The augite of the Alban Hills has not been much studied, although it is one of the most abundant and most prominent minerals of the district, and has been known for about one hundred and fifty years. An analysis by Klaproth, made in 1810, gives a remarkably close approximation to its chemical composition. The latest general description (chiefly crystallographic) is that of Zambonini,[2] who gives a full bibliography to 1899. Later papers on Alban augite have been published by Viola and Kraus,[3] and by Parravano.[4]

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[1] L. D. Adams and E. D. Williamson, *Jour. Franklin Inst.*, **195**, 482, 1923.

[2] F. Zambonini, *Zeits. Kryst.*, **33**, 39, 1900.

[3] Viola and Kraus, *Zeits. Kryst.*, **33**, 36, 1900.

[4] Parravano, *Rend. Accad. Lincei*, **21**, 469, 1912.

There seems to be considerable variation in the characters and the composition of Alban augite. According to Zambonini there is a black and a light green variety, the former being much the more abundant. Viola recognizes another, stated to be intermediate between aegirite and aegirite-augite, which he calls fedorowite. Von Rath[5] describes very briefly a green augite, occurring in ejected blocks in peperino (tuff), which has a habit markedly different from the crystals described by us.

From among the several specimens kindly sent us by Professor Millosevich, all of which are of the black variety, we selected for study a batch of loose crystals from the Fosso del Tavolato, on the Via Appia Nuova, a few kilometers southeast of Rome. Crystals of the same general habit and characters occur in the solid tuffs, near Ariccia and at many other localities, and the loose crystals studied by us have presumably the same origin.

TABLE I. ANALYSES OF AUGITE, ALBAN HILLS

	1	2	3	4	5	6	7
SiO_2	48.11	48.86	52.36	44.53	53.81	48	49.69
TiO_2	1.19	0.37	n.d.	0.69	0.44	n.d.	0.14
Al_2O_3	5.45	5.23	2.42	10.29	10.82	5	3.31
Fe_2O_3	4.42	1.71	2.24	2.95	2.13	12	6.30
Cr_2O_3	0.06	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
FeO	3.74	10.02	1.94	9.14	1.27	n.d.	0.71
MnO	0.09	0.23	n.d.	0.04	n.d.	1	1.13
MgO	12.03	8.35	14.53	5.78	7.54	8.75	14.57
CaO	24.50	24.34	24.57	25.22	22.46	24	20.26
Na_2O	0.46	n.d.	2.05	n.d.	0.86	n.d.	2.15
K_2O	none	n.d.	none	n.d.	n.d.	n.d.	0.68
H_2O+	0.09	n.d.	n.d.	0.04	0.34	n.d.	1.22
	100.14	99.12	100.11	98.66	99.78	98.75	100.16
D	3.373	3.441				3.40	3.26

1. Augite (black), Fosso Tavolato. Washington analyst.
2. Augite (bottle green), Frascati. Zambonini analyst. *Zeits. Kryst.*, **33**, 54, 1900.
3. Augite (light green), Alban Hills. Viola and Kraus, *Zeits. Kryst.*, **33**, 37, 1900. Mean of two.
4. Augite (black), Fosso Tavolato. N. Parravano, analyst. *Rend. Accad. Lincei*, **21**, 469, 1912. Sum given as 99.77.
5. Augite (dark green), Castelnuovo del Porto. N. Parravano, *op. cit.* Includes 0.07 H_2O-.
6. Augite (black), Frascati. Klaproth analyst. *Beitr.*, **5**, 166, 1810. Cited in Hintze, Handb. Min., II, 1040 note 1, 1897.
7. Augite, (brown), Fiano, Phlegrean Fields. Zambonini analyst. *Mem. carta, Geol. Ital.*, **7**, (2), 94, 1919.

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[5] Von Rath, *Zeits. Deut. Geol. Ges.*, 543, 1866.

The augite crystals, from 1 to 2 centimeters in greatest dimension (vertical), are mostly rather rough, with dull faces; they are quite free from scoria. They all show the most common planes, *a*(100), *b*(010), *m*(110), and *s*($\bar{1}$11), and their general habit is that usual with such volcanic augites. L. H. Adams determined the *density* as 3.373 at 29°.

On fresh fracture surfaces the color is a lustrous black. Sections 3 mm. thick are dull greenish yellow, between 25″k and 25‴i of Ridgway; the washed powder, 0.1 to 0.01 mm. grains, is between 25‴k and 25⁗k.

Microscopic examination shows that the material is slightly zoned, but on the whole fairly uniform, and that it is very free from inclusions. The refractive indices show extreme variations of about ±0.004 from the following values, estimated from measurements; $\alpha=1.703$, $\beta=1.710$, $\gamma=1.727$ (H. E. M.).

An analysis was carried out on carefully selected material and gave the results shown in column 1 above.

It is of interest to note the presence of a small amount of chromium and the entire absence of potash in our analysis. Viola and Kraus state that potash was not detectable spectroscopically in the augite which they analyzed.

The analysis of our material from the Alban Hills resembles, in general, analyses of other volcanic augite which we have published, such as those of Vesuvius and Etna,[6] Haleakala,[7] and Kilimanjaro.[8] These are all much alike in their content of silica, titania, magnesia, soda, and potash; and show somewhat variable but not widely diverse amounts of alumina and the iron oxides. Lime, however, is notably higher in the Alban Hills augite, 24.5 per cent as against about 21.5 in the others. The relatively high lime is remarkable, inasmuch as the above augites with less lime occur either in considerably more calcic lavas (Haleakala), or in those which contain about the same percentage of lime as the Alban rocks (Etna), as well as in some with less (Vesuvius). This is a matter, however, which must be postponed to a future general discussion of the composition and occurrence of volcanic augite. The entire absence of potash is remarkable in view of the fact that the lavas of the Alban Volcano are highly potassic, being uniformly either albanite,[9] (leucitite) or melilite albanite.

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[6] Washington and Merwin, *Am. Jour. Sci.*, **1**, 22 and 29, 1921.

[7] Washington and Merwin, *Am. Jour. Sci.*, **3**, 119, 1922.

[8] Washington and Merwin, *Am. Mineralogist*, **7**, 123, 1922.

Zambonini's analysis resembles ours closely in silica, alumina, and lime, the differences in the minor constituents being insignificant, while he neglected to determine the alkalies. But his iron oxides differ widely from ours, their total amount being higher, and ferrous oxide dominating greatly over ferric; and his magnesia is decidedly lower than in ours. Although he calls his analyzed augite "black," he states that it is bottle green in small pieces, while ours is black in small fragments a few millimeters thick, except on the thin edges.

The analysis by Viola and Kraus is unsatisfactory, their value for soda being almost certainly too high. The high silica, magnesia, and lime, and the low iron oxides are in harmony with the light green color; but there is not enough ferric oxide to satisfy the two per cent of soda in forming acmite, even if all the iron oxide be reckoned as ferric. This will be referred to later. It would seem that they used the old Berzelius method of decomposition for alkalies, and separated the magnesia from the alkalies by mercuric oxide, the soda being weighed as sulphate. This method tends to yield too high figures for the alkalies.

The analyses by Parravano also are very unsatisfactory. Both of them show an inordinate amount of alumina and a correspondingly low figure for magnesia, so that we may assume that some of the magnesia has been weighed with the alumina, which is one of the most frequent analytical errors. That this is so is indicated on calculations of the molecular composition. Analysis No. 4 yields more than 20 per cent of the wollastonite molecule, while with No. 5 we obtain 22.5 per cent of wollastonite and also about 14 per cent of excess silica.

It is of interest to turn to the analysis by Klaproth, made more than one hundred years ago. Its close similarity to the analysis by Zambonini is striking testimony to Klaproth's skill as an analyst. The two augites may not have been identical, although they came from the same locality, but they surely cannot have differed very widely. It is to be remembered that in Klaproth's day there was no good method for the separate determination (in silicates) of ferrous and ferric oxides. If all of Zambonini's iron oxides are calculated as ferric we obtain a total of 12.84 per cent, which is not far from the 12 per cent found by Klaproth.

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[9] H. S. Washington, *Am. Jour. Sci.*, **50**, 47, 1920; *Rend. Accad. Lincei*, **29**, 435, 1920.

We have added an analysis by Zambonini of an "acmite augite" from the tuffs of the Phlegrean Fields, near Naples. Pleochroism is not mentioned. This is low in silica and lime, and high in magnesia and soda.

We may now calculate the composition of these augites in terms of their constituent molecules, assuming that soda enters acmite, the alumina and the ferric oxide in excess of that used for acmite are present in solid solution and not in the Tschermak molecule,[10] and that TiO_2 replaces SiO_2.

TABLE 2. MOLECULAR COMPOSITION OF ALBAN AUGITES.

	1	2	3	4	5
Diopside ($CaMgSi_2O_6$)....	65.02	45.14	78.41	31.32	40.82
Hedenbergite ($CaFeSi_2O_6$).	13.15	35.21	none	31.49	4.47
Wollastonite ($CaSiO_3$).....	9.63	9.63	8.82	20.65	22.50
Acmite ($NaFeSi_2O_6$)......	3.23	(3.23)	15.25	.....	6.47
$Al_2O_3+Fe_2O_3$............	9.41	6.44	2.42	13.24	10.82
Excess SiO_2..............	none	none	none	1.89	14.22
	100 44	100.65	104.90	98.59	99.30

The molecular amount of SiO_2 needed for the composition of No. 1 is .819, while the analysis shows $SiO_2+TiO_2=.817$. Zambonini did not determine the soda in his augite, but when the composition is calculated on the assumption that no acmite is present there is an excess of silica which, oddly enough, is exactly that needed for the amount of acmite shown in our analysis, No. 1. We have, therefore, assumed that about 0.46 per cent of soda is present in Zambonini's augite. The molecular composition as thus calculated differs from Zambonini's in that he considers the aluminous and ferric Tschermak molecules to be present, and does not allow for acmite; on making these modifications his calculated composition agrees with our calculation from his data.

Our augite, from Fosso del Tavolato, is eminently rich in diopside, $MgSiO_3$, with little hedenbergite and with some wollastonite. Zambonini's, on the other hand, is rich in hedenbergite, but has the same amount of wollastonite as ours. Both contain a small amount of acmite. The presence of the wollastonite molecule is somewhat remarkable, inasmuch as none of the other augites studied by us show this but, on the contrary, an excess of the hypersthene molecule $(Mg,Fe)SiO_3$. The differences in density between our and Zambonini's Alban augite are in accord with the chemical differences, and the differences in color would also seem to be in harmony, although we know too little of the optical characters of Zambonini's mineral to permit of proper comparison.

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[10] It is to be remembered that the amount of silica needed to satisfy (Mg,Fe)O is the same, whether $(Al,Fe)_2O_3$ is assumed to be present in the Tschermak molecule (e.g. $MgO.Al_2O_3$, SiO_2) or is in solid solution in $MgO.SiO_2$.

Even though Viola and Kraus' analysis is not satisfactory, yet its main features are sufficiently clear to permit us to believe that their light green augite is essentially diopside, with some wollastonite and with a little acmite, less than is indicated by their soda determination but sufficient to render the augite pleochroic. Zambonini did not make a complete analysis of his light green augite because of the paucity of material, but he determined the iron oxides with the result Fe_2O_3 5.58 and FeO 0.60 per cent, while in another crystal of like color he obtained 4.37 per cent of FeO. These results indicate that, although there is considerable variation in its composition, his light green augite is probably closely similar to that of Viola and Kraus.

A word must be said as to Viola and Kraus calling their Alban Hills augite "fedorowite." This name was applied originally by Viola[11] to a monoclinic pyroxene, occurring in the Hernican District south of Rome, "intermediate between aegirite and aegirite-augite, with 9–13 percent of alkali [soda] and about 24 per cent of FeO." Its extinction angle is given at 65°–75°. It is evident that, quite apart from the inadvisability of bestowing a new name on a merely intermediate variety of a mineral group which is already more than sufficiently baptized, the augite from the Alban Hills described by Viola and Kraus does not accord chemically with the definition of the original "fedorowite" from the Hernican District, and it corresponds optically only in being pleochroic and (in the fragments selected) roughly in extinction angle. We may therefore reject the name "fedorowite" as applied (at least) to the Alban light green pyroxene, and consider it as a slightly acmitic diopside.

Although, as we have seen, they are both unsatisfactory, yet Parravano's analyses indicate that a hedenbergitic augite occurs at Fosso Tavolato (No. 4) and that an acmitic diopside, much like that of Viola and Kraus, occurs elsewhere at the Alban Volcano (No. 5).

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[11] C. Viola, *Neues Jahrb.*, **1**, 121, 1899. No analysis of the Hernican augite was given.

It seems to be clear that there is a very considerable variety in the characters of the augites at the Alban Volcano, which is the more remarkable in view of the fact that this volcano, of all those along the Bolsena-Vesuvius line, shows the greatest uniformity among its lavas.

AN ALLEGED OCCURRENCE OF THE $\alpha CaO.SiO_2$–$3CaO.2SiO_2$ EUTECTIC

Samuel G. Gordon, *Academy of Natural Sciences of Philadelphia*

In March, 1923, a brownish mass, 5x3x2 cm., was sent to the writer for identification, which upon optical investigation proved to be a mixture of the compounds $\alpha CaO.SiO_2$ (pseudowollastonite), and $3CaO.2SiO_2$. A thoro study of the material was made, followed by a visit to the supposed locality, near Spartanburg, S. C.

The mass showed the following properties: color, ivory-yellow to brown; luster, vitreous to greasy; translucent; hardness, about 5.5; specific gravity, 2.86. One surface showed distinct, but very brittle crystalline plates. The mass gelatinizes in HCl.

A thin section revealed the mass to be a eutectic mixture, and an analysis by Dr. J. Edward Whitfield established its identity with the binary eutectic obtained by Rankin and Wright[1] at 1455°C. in their investigation of the system $CaO–Al_2O_3–SiO_2$ at the Geophysical Laboratory. An analysis of the Spartanburg material as well as the binary eutectic are given below for comparison.

	A	B
SiO_2	44.34	45.5
Al_2O_3	2.28	——
Fe_2O_3	0.40	——
CaO	52.05	54.5
MgO	0.56	——
	99.63	100.0

A. Analysis of Spartanburg material, by Dr. Whitfield.
B. Binary eutectic, $\alpha CaO.SiO_2$–$3CaO.2SiO_2$.

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[1] *Am. J. Sci.*, **39**, 1-79, 1915.

The two compounds showed the following optical properties, which are essentially identical with those recorded by Rankin and Wright:

			α	β	γ
$\alpha CaO.SiO_2$	Monoclinic	+	1.612		1.654
$3CaO.2SiO_2$	Monoclinic	+	1.642	1.643	1.650

The $3CaO.2SiO_2$ compound is monoclinic, shows a perfect cleavage parallel to (100), and an extinction angle in the plane of symmetry ($X \wedge c$) of 15°.

The specimen was brought in by a student and given to Prof. W. G. Blake of the high school. He in turn took it to Prof. D. A. Dupre of Wofford College, who sent it to Mr. George L. English, from whom the writer received it.

The student upon questioning gave evasive answers, but stated that he had found it on Cedar Springs branch, about 3 miles southeast of Spartanburg, S. C. Examination of the branch, and the hillsides on each side revealed only schists and gneisses.

Spartanburg is situated on the Carolina, Clinchfield and Ohio Railroad, which is stated to be ballasted in part by slag, near the city. Situated also on this railroad, 185 miles to the north, is Kingsport, Tenn., with a large cement plant, (the most probable source of the material). It seems to the writer that the student found the specimen along the railroad, and realizing its artificial character by the associated material, took it to his instructor with the idea of puzzling him (a not uncommon trick of students).

PROCEEDINGS OF SOCIETIES

JOINT MEETING OF THE NEW YORK MINERALOGICAL CLUB AND THE NEW YORK MICROSCOPICAL SOCIETY

A joint meeting of the New York Mineralogical Club and the New York Microscopical Society was held in the west Assembly Room of the American Museum of Natural History on Wednesday evening, February 14, at 8.00 P.M. The President of the New York Mineralogical Club presided. There was an attendance of 45 members of the two organizations.

The reading of the minutes of the last meeting was dispensed with and the Chair introduced Mr. Thomas P. Clendenin of Columbia University who delivered a highly interesting address on "*Minerals Under the Microscope.*"

Through the courtesy of Mr. Dwight L. Elmendorf of the Microscopical Society a special projection stand devised and operated by Mr. Elmendorf was used, which projected upon the screen with striking clearness the illustrative slides used by the speaker giving remarkably brilliant effects under polarized light and showing very sharp figures with convergent light. The speaker in describing the petrographic microscope, characterized it as an optical machine. He described the preparation of the slide by which minerals are studied under the microscope, and explained a number of rock section slides illustrating the characters by which minerals are distinguished both in plain light and with polarized light effects.

At the close of his address a vote of thanks was tendered to Mr. Clendenin for his highly illuminating paper. Dr. Kunz spoke briefly on the recent deaths of the two eminent mineral collectors, Norman Spang and Clarence S. Bement. The meeting then adjourned.

Herbert P. Whitlock, *Recording Secretary*

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences, April 12, 1923

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the president, Mr. Vaux, in the chair. Twenty-two members and two visitors were present.

Upon favorable recommendation of the council, Messrs. Andrew Mantz and Frank K. Pickel were elected to active membership.

Mr. Horace Blank addressed the society on "*The Constitution of Complex Minerals*," or those that are compounds of higher order, composed of two or more saturated compounds. The history of the theories of valence was reviewed, in particular the dualistic theory of Berzelius; followed by a detailed account of Werner's coördinate extension of the notions of valence, with the ideas of primary and secondary valence. Coördinate formulas of many substances were presented, and it was shown how the salts of hetero-polyacids and iso-polyacids might be explained on this basis.

Mr. Oldach reported on the trip to Perkiomenville on March 25th, participated in by Messrs. Hallowell, Hilbiber, Tallis, Clay, Trudell, Knabe, Broadbelt, and himself. Considerable stilbite was obtained.

Samuel G. Gordon, *Secretary*

BOOK REVIEWS

HANDBOOK AND DESCRIPTIVE CATALOGUE OF THE COLLECTIONS OF GEMS AND PRECIOUS STONES IN THE UNITED STATES NATIONAL MUSEUM. George P. Merrill, assisted by Margaret W. Moodey and Edgar T. Wherry. *Bull. U. S. Nat. Museum,* **118,** 1922.

This handbook is a new edition, largely rewritten, of a descriptive catalogue of the gem collections in the National Museum, published in 1902. Preceding the catalogue proper are short chapters on the history and arrangement of the collections, and on names, physical and chemical properties of precious stones.

In the catalogue of the gem collections, the gem minerals are arranged alphabetically. Each is briefly described giving physical properties, composition, occurrence, and miscellaneous information of interest. The individual specimens are then listed and rather fully described; name, locality, cut, color, weight, measurements, and number being given.

Following this are the catalogues of related collections; rough and cut stones, imitation stones, synthetic stones, models of cuts, ornamental objects not used for personal adornment, and the collection illustrating the occurrence and association of gems (miscellaneous series, South African diamond-bearing rocks, pegmatites of the Appalachian region and of Mesa Grande, Calif.).

Appendices include: the cutting of gem stones; gems mentioned in the Bible; mystical properties of gems; lists of gem and mineral names; industrial uses of precious stones; tables for the identification of gems by their physical and optical properties; statistics of production, 1913-1918; and a selected bibliography on gems. A number of plates show photographs of gem mines in this country. There are two colored plates of gems, as well as a number of text figures.

While primarily a catalogue, much of the information contained in this handbook is of general interest to mineralogists, as well as the laity. The remarks on cause of color and absorption spectra of gems, and the determinative tables for gems, may be mentioned in this connection. EDW. F. HOLDEN

ANNUAL TABLES OF CONSTANTS AND NUMERICAL DATA. Vol. IV, part I, XXXII+626 pages, *1921;* part II, XXXVII+751 pages (pp. 627-1377), *1922.* Gauthier-Villars et Cie (*Paris*); The Cambridge University Press (*Cambridge*); University of Chicago Press (*Chicago*). Net $13.25 each; postpaid $13.57.

The publication of the Annual Tables of Constants and Numerical Data, interrupted by the World's War, has again been resumed so that the two volumes recently published mark the first appearance of this exceedingly valuable reference work since 1914. The two volumes, comprising 1377 pages, contain practically all the numerical data published during the period 1913 to 1916 inclusive, as revealed by a digest of 341 periodicals. In a monumental undertaking of such proportions some omissions are inevitable, nevertheless, the accomplishment deserves the unstinted praise of all scientists. (The reviewer has looked in vain for any reference to THE AMERICAN MINERALOGIST in the list of periodicals reviewed, altho this Journal was established in 1916.)

While the treatment accorded Metallurgy and Engineering is unusually exhaustive, the mineralogist and crystallographer will be especially interested in the 65 pages of volume II, (pp. 1026-1901), devoted to the following subjects: optical constants and analyses of minerals (arranged alphabetically); new forms of minerals; crystallography of inorganic and organic substances; fusibility of minerals; variation of crystal angles with temperature and structure of crystals. W. F. H.

NOTES AND NEWS

APATITE CRYSTAL-CAVITIES. EDGAR T. WHERRY, *Washington, D. C.*—The District of Columbia and its immediate vicinity is such poor territory from the standpoint of the mineral collector that announcement of even a negative mineral occurrence may be worth while. In the vicinity of Chevy Chase, which lies along the northwest boundary, partly in the district and partly in Montgomery County, Maryland, several minerals can be found loose in the soil. Most abundant and conspicuous is vein quartz, in masses up to several meters in diameter. Irregular cavities in this occasionally contain quartz crystals, both colorless and somewhat smoky, up to 10 cm. in length; and the micaceous margins of the quartz veins often show 1 to 2 cm. cubes of limonite pseudomorphous after pyrite. Both quartz and pyrite crystals commonly weather out, and are to be picked up in road gutters and rain gullies in the fields.

Imbedded in the solid vein quartz occur tiny brownish-black tourmaline crystals, and plates of ilmenite as much as 10 cm. across. But perhaps the most interesting feature of the vein quartz is the presence in it of crystal-cavities. Some of these are cubical in shape, clearly representing pyrite which has dissolved away instead of becoming limonitized; but more often they are prismatic and hexagonal in outline, a few cm. in length and usually less than a cm. thick. It recently occurred to the writer that it would be interesting to determine the nature of the mineral represented by these cavities, so a series of them was collected, and modelling-clay impressions of their terminations made. The *rho* angle of the pyramid occasionally present was found to be 40°, suggesting that their parent mineral was apatite. Confirmation of this was obtained by examining vein quartz in the National Museum collection from the dumps of a water tunnel run under the western end of the District of Columbia some years ago. This showed plates of ilmenite and fresh green apatite crystals of the same general dimensions and habit as the Chevy Chase crystal-cavities.

F. N. Guild of the University of Arizona calls attention in *Science* (April 20, p. 471) to the possibility of mistaking war explosives, which have been exposed to atmospheric agencies, for minerals. T. N. T. (trinitrotoluene) when exposed to light turns yellow to brown and when broken may reveal a fibrous, radiating appearance not unlike some minerals. During the past year a number of specimens have been received at the Arizona Bureau of Mines resembling somewhat carnotite, but the bitter taste and the dyeing of a piece of filter paper was sufficient to identify the material.

Science News (*Science*, April 20, p. IX) reports an exceedingly interesting experiment by Dr. Paul R. Heyl of the Bureau of Standards. A large topaz crystal, borrowed from the United States National Museum, is being weighed in various positions to test the validity of the Einstein theory of gravitation. A balance is employed that is so delicate that it will weigh three pounds with an error of not more than one part in a billion. The results, altho only one-fifth completed, confirm the views of Einstein.

Professor Charles Palache has been appointed curator of the mineralogical museum at Harvard to take office next September, in place of Professor John E. Wolff, whose plan to retire from active teaching next summer was recently announced.

It has been announced that Dr. Esper S. Larsen of the United States Geological Survey has accepted the Professorship of Petrography at Harvard University, succeeding Professor J. E. Wolff, who retires this year.

Reprints of Professor A. F. Rogers' article, "The Use of Plans and Elevations in the Study of Geometrical Crystallography," which appeared in the February issue of THE AMERICAN MINERALOGIST, may be obtained from the Stanford Bookstore, Stanford University, California, for 25 cents each postpaid, 10 or more for 20 cents postpaid.

A plant for the quarrying and finishing of garnet for use in the automobile manufacturing industry will be erected near Danbury, New Hampshire by the Ford Motor Company.

Attention is called to the change of address of George S. Scott, dealer in high grade mineral specimens and rare ores, from 20 Nassau St., to *342 Madison Ave., New York City.*

Dr. Fred Wright, petrologist at the Geophysical Laboratory, has been elected to the National Academy of Sciences.

Dr. Karl Mieleitner of Munich, Curator of the State Mineralogical Collection of Bavaria, died on March 15th. He was associated with Professor Groth in compiling the recently reviewed Tabellarische Uebersicht der Mineralien.

Remarkable photographs of high speed collisions of the nuclei of atoms obtained by the use of a moving picture machine were shown by Dr. William Draper Harkins, of Chicago University, in a series of lectures at Carnegie Institute of Technology, Pittsburgh. A new discovery by use of the photos was that the helium nucleus, used as a projectile, rebounds in a backward direction while the nucleus of the nitrogen atom which is struck is projected forward; both at speeds of several thousand miles per second.

NEW MINERALS: NEW SPECIES

CLASS: SULFIDES. DIVISION: $R' : R'' : R''' : R''''=5 : 6 : 1 : 1$. (?)

"Germanite"

O. Pufahl: Germanite, a new germanium mineral and ore from Tsumeb, S. W. Africa. *Metall und Erz*, **19**, 324, 1922; through *Chem. Abstr.*, **16**, 3608, **1922.** (Original not seen.)

Name: From the presence of the element *germanium.*

Chemical properties: *Formula,* approximately $5Cu_2S.12(Cu,Fe)S.As_2S_3$.—$2GeS_2$ or $Cu_5\,(Cu,Fe)_6\,As\,GeS_{12}$, the theory for which is (for all copper): Cu 56.8, As 6.1, Ge 5.9, S 31.2, sum 100.0%. Analysis gave Cu 45.4, Fe 7.2, As 5.0, Ge 6.2, S 31.3, sum 95.1%.

Physical properties: Color dark reddish gray; luster metallic; structure massive. Sp. gr. = 4.46.

Occurrence: Found intergrown with tetrahedrite at Tsumeb, Africa.

Discussion: While a new species is probably represented here, its composition can not be regarded as established, for the material analyzed may not have been homogeneous, and the analysis is rather incomplete. A relationship to ultrabasite (abstracted in *Am. Min.*, **6**, (3), 63–64, 1921), suggests itself, although that mineral appears to be somewhat more basic: ($R' : R'' : R''' : R''''=6 : 8 : 1 : 1$).

E. T. W.

CLASS: PHOSPHATES, ETC. DIVISION: $R'' : R''''' : P : H_2O=1 : 2 : 2 : X$.

Meta-torbernite I

Hallimond, A. R.: The crystallography and dehydration of torbernite. *Min. Mag.*, **17**, 326–339, 1916: *Am. Min.*, **1**, 52, 1916. Meta-torbernite I, its physical properties and relation to torbernite. *Min. Mag.*, **19**, 43–47, 1920. Bowen, N. L.: Abnormal birefringence of torbernite. *Am. J. Sci.*, [4], **48**, 195–198, 1919; *Am. Min.*, **5**, 20, 1920.

NAME: A translation of the German "metakupferuranit I" (Rinne, 1901); comprises the prefix *meta*, which is commonly used to indicate alteration or variation, *torbernite*, the high-water species of the same anhydrous composition, and the roman numeral *I*, referring to the fact that this is the first product obtained on heating torbernite.

CHEMICAL PROPERTIES: A representative of torbernite, but lower in water: $Cu\ (UO_2)_2\ (PO_4)_2.\ (8H_2O)$.

CRYSTALLOGRAPHIC PROPERTIES: Tetragonal, in plates; $a : c = 1 : 2.28$.

PHYSICAL AND OPTICAL PROPERTIES: Sp. gr. 3.68. Refractive indices (D): $\omega = 1.623$, $\epsilon = 1.625$, thus showing weak, + birefringence. Otherwise resembling torbernite.

OCCURRENCE: Originally recognized as an artificial product. First noted as occurring in nature by Bowen, *loc. cit.*, the localities being Spain and Cornwall, the latter being given more specifically by Hallimond as at Gunnislake.

DISCUSSION: The behavior of the water in torbernite indicates that 4 molecules of it are held in layers alternating with basal layers of meta-torbernite I. The latter is now to be accepted as an independent species. E. T. W.

REDEFINITION OF SPECIES

CLASS: HALIDES. SUB-CLASS, OXY-HALIDES. DIVISION: $R'' : F : O = 3:4:1$.

Nocerite

A. SCACCHI, 1881. Redefined by F. ZAMBONINI: The pipernoid tuffs of Campania and their minerals. *Mem. serv. descr. carta geol. Italiana,* **7**, pt. 2, 1919; through *Z. Krist.*, **56**, 219–220.

CHEMICAL PROPERTIES: Formula, $Mg_3Ca_3F_8O_2$. Analysis gave: Ca 27.97, Na 2.19, Li trace, K 0.69, Mg 18.18, Fe 0.59, Mn 0.03, F 40.08, Cl trace, O 8.30, H_2O 1.50, sum 99.53%.

CRYSTALLOGRAPHIC AND OPTICAL PROPERTIES: Hexagonal, with the two prisms, the base, and indeterminate pyramids. Uniaxial negative with $\omega_D = 1.5084 - 1.5098$, $\epsilon_D = 1.4855 - 1.4856$.

PHYSICAL PROPERTIES: Colorless, brownish or rarely greenish; transparent and lustrous; sp. gr. 2.96.

OCCURRENCE: With fluorite in limestone blocks in the tuffs of the Italian Campania.

DISCUSSION: This mineral is evidently a well-marked oxyhalide, perhaps belonging in a group with penfieldite, which is $Pb_3\ Cl_4\ O$. E. T. W.